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CLEAN VERSION OF AMENDED APPLICATION

SI01-011

OPTICAL COUPLING DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority under 35 U.S.C. § 119 of German Patent Application No. 19934178.8, filed July 21, 1999, and is a national stage filing under 35 U.S.C. § 371 of PCT Application No. PCT/DE00/02397, filed July 21, 2000.

FIELD OF THE INVENTION

[0002] The invention relates to an optical coupling device for cross-coupling light from a first optical waveguide into a second optical waveguide. Such a coupling device is known, for example, from WO 98/13718.

BACKGROUND OF THE INVENTION

[0003] Coupling devices are used in optical filters according to the phased-array principle with an injection face in which light enters at a specific geometrical position, the geometrical position influencing the output wavelength of the optical filter. Such optical filters according to the phased-array principle are used, in particular, as multiplexers or demultiplexers in optical wavelength multiplex operation (WDM), since they exhibit low insertion attenuation and high cross-talk suppression. The optical filter has, as its essential component, a plurality of curved optical waveguides of different length, which form a phase-shifter region. German Patent Application DE 44 22 651.9 describes that the central wavelength of a phased-array filter can be established through the position of an injection optical waveguide, which guides the light into the layered optical waveguide. In this way, the central wavelength of the optical filter can be adjusted accurately through the geometrical positioning of the injection optical waveguide or the injection fibre. Since it is therefore desirable for the optical waveguides to be displaced relative to one another, the optical waveguides cannot be adhesively bonded to one another.

SUMMARY OF THE INVENTION

[0004] In the optical coupling device cited in the introduction, a first holding block is fixed to the chip and the optical fibre is held on the variable-length element. In this case, the variable-length element can oscillate or bend, which causes temporary or permanent deadjustment of the fibre.

[0005] The invention is therefore directed to ensuring improved guidance of the variable-length element parallel to its main extension direction and, in the process, to avoid additional effort. This is achieved by an optical coupling device having the features specified in Patent Claim 1.

[0006] Since the guide element has a second holding block as an abutment on which the variable-length element is guided parallel to its main extension direction, improved guidance of the variable-length element parallel to the coupling face is ensured in a simple way, and additional effort is avoided.

[0007] By means of this arrangement, varying the length of the variable-length element is made possible, but the movement of the element in the abutment is restricted only in the dimension perpendicular to the expansion direction of the variable-length element. At the same time, the guidance of the moveable axis is very accurate, so that any movements in the direction of the fixed axis are smaller than 1 micrometer. This means that the movement of the first optical waveguide (fibre) relative to the second optical waveguide (strip conductor) present on the optical component (chip or planar waveguide) takes place very exactly parallel to the surface of the component, and that deadjustment in other spatial directions virtually does not occur.

[0008] A further advantageous configuration of the coupling device according to the invention is that the guide element has a ferrule which is connected to the variable-length element and is mounted in a hole in the second holding block such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place. At the same time, it is advantageous if the ferrule is guided in a suitable, commercially available coupling sleeve in the second holding block, which serves as an abutment.

[0009] A further advantageous configuration of the coupling device according to the invention is that the guide element has a ferrule that is connected to the second holding block and is mounted in a hole in the variable-length element such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place. At the same time, it is advantageous if the ferrule is guided in the variable-length element via a sleeve.

[0010] In particular as the result of using a ferrule, for example a commercially available optical waveguide plug ferrule, which is fitted in the longitudinal direction of the variable-length element, particularly accurate guidance can be achieved.

[0011] A further advantageous configuration of the coupling device according to the invention is that the guide element is formed by a tongue-and-groove connection between the variable-length element and the second holding block. A guide element which is mechanically simply implemented is therefore provided, without having to make recourse to additional components.

[0012] A further advantageous configuration of the coupling device according to the invention is that the second holding block has a U-shaped cross section, and in that the variable-length element is guided in the U-shaped cross section of the second holding block. In this case, the result, on both sides of the variable-length element, is guide faces which ensure appropriately exact guidance. This provides an optical coupling device in which the optical connection between an optical fibre and an optical chip is achieved with high security and stability with cost-effective mounting.

[0013] A further advantageous configuration of the coupling device according to the invention is that an abutment is fixed to the variable-length element and acts in a displaceable manner on the second optical waveguide, the abutment advantageously having, on one side, a spring between one end of the abutment and the second optical waveguide and, on the other side, a setting screw between another end of the abutment and the second optical waveguide. The abutment fitted to the variable-length element is able to slide along the second optical waveguide. By means of the screw, the pressure and the position perpendicular to the surface of the second optical waveguide can be adjusted.

[0014] In coupling devices of the aforementioned type, hitherto the fibres have been adhesively bonded into V-grooves, and the cavities produced in the process have been filled with adhesive. Since the adhesive exhibits a different behaviour with respect to temperature, expansion coefficient, water absorption and the like from the fibres and holding blocks and, respectively, the variable-length element, stresses in the adhesive and therefore deadjustment of the fibre can occur under changing ambient conditions. This may be avoided by the fibre being anchored, in particular adhesively bonded, in a ferrule arranged in a hole in the variable-length element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Exemplary embodiments of the invention will be explained in more detail below using the drawings, in which:

[0016] Figs. 1A and 1B show a side view and an end view, respectively, of a coupling device according to one exemplary embodiment of the invention;

[0017] Figs. 2A and 2B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

[0018] Figs. 3A and 3B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

[0019] Figs. 4A and 4B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

[0020] Fig. 5 shows the schematic construction of the connection between the variable-length element and an optical fibre;

[0021] Fig. 6 shows a side view of the device according to Fig. 1; and

[0022] Fig. 7 shows an optical fibre array to be coupled to optical chips, with many parallel optical waveguides.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Fig. 1A shows, as a first optical waveguide, a fibre 2 which is fixed via a ferrule 4 in a variable-length element 6. The element 6, produced from aluminium, for example, is fixed, in particular adhesively bonded, to a holding block 8 (glass or glass ceramic), which, in turn, is fixed or adhesively bonded to a second optical waveguide 10, an optical waveguide chip (also known as a planar waveguide) in this example.

[0024] Arranged at the free end 12 of the variable-length element 6, in an appropriate hole 14, is a ferrule 16, which projects beyond the free end 12 of the variable-length element 6. The free end of the ferrule 16 is mounted via a guide sleeve 18 in a second holding block 20, so that the variable-length element 6 can extend in the direction of its longitudinal axis but, on the other hand, cannot give way in the spatial directions orthogonal thereto. Since the ferrule 16 and the sleeve 18 are tried and tested standard components, secure guidance of the variable-length element 6 in the longitudinal axis of the same is ensured. Alternatively, the ferrule 16 can be fixed firmly in the holding block 20 and mounted such that it can slide in the variable-length element 6.

[0025] Fig. 2A shows, as a first optical waveguide, a fibre 22, which is fixed via a ferrule 24 in a variable-length element 26. The variable-length element 26 is fixed or adhesively bonded to a holding block 28, which in turn is fixed or adhesively bonded to a second optical waveguide 30, an optical waveguide chip in this example.

[0026] Provided in one end 32 of the variable-length element 26 is a groove 34, which acts on a corresponding tongue 36 on a second holding block 38 and in this way forms a tongue-and-groove connection between the variable-length element 26 and the second holding block 38.

[0027] In Fig. 3A, a fibre 42 is illustrated as the first optical waveguide being fixed via a ferrule 44 in a variable-length element 46. The variable-length element 46 is fixed or adhesively bonded to a holding block 48 which, in turn, is fixed or adhesively bonded to a second optical waveguide 50, an optical waveguide chip in this example.

[0028] At its free end 52, the variable-length element 46 is mounted on a holding block 54 with a U-shaped cross section, the variable-length element 46 being guided in the U-shaped cross section of the holding block 54. With its two legs 56, 58, the holding block 54 therefore engages around the front end 52 of the variable-length element 46, so that the latter is likewise satisfactorily guided.

[0029] In 4A, a fibre 62 is shown as the first optical waveguide, being fixed via a ferrule 64 in a variable-length element 66. The variable-length element 66 is fixed or adhesively bonded to a holding block 68 which, in turn, is fixed or adhesively bonded to a second optical waveguide 70, an optical waveguide chip in this example.

[0030] Fixed to the end of the variable-length element is an abutment 72 which engages in a displaceable manner on the second optical waveguide 70. As can be seen from Fig. 4B, the abutment 72 has a U-shaped cross section and is supported with one leg 74, via a spring 76, on one side of the second optical waveguide 70 and, on the other side, via a setting screw 80 arranged on the other leg 78 of the abutment 72, on the second optical waveguide. By means of the setting screw 80, the pressure and therefore the position of the variable-length element 66 can be adjusted.

[0031] A rectangular, elongate, variable-length element 82 is illustrated in end view in Fig. 5 and in side view in Fig. 6. The variable-length element 82 is fixed to a holding block 84, which is adhesively bonded onto the surface of an optical chip (not shown). The element 82 is connected to the holding block 84, likewise at one end.

[0032] A commercially available ferrule 86 is fixed into the element 82, in an appropriate hole 88. Fixed in the ferrule 88 is an optical fibre 90. The ferrule 88 can either be installed vertically into the element 82 or at an angle, in order to reduce reflections at the end face of the fibres. The ferrule can also be a multiple fibre ferrule.

[0033] Fig. 7 shows a group of fibres in a block 92, the fibres 90 in each case being arranged in a ferrule 86, which are in turn inserted or adhesively bonded into corresponding holes 88 in the block 92.